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BOATER DECISION-MAKING

Wyle Laboratories
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NOVEMBER 1976

FINAL REPORT

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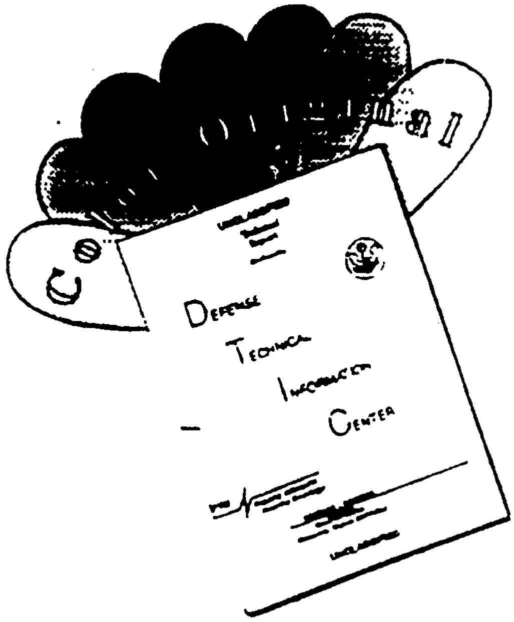

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16. Abstract

This report summarizes work completed under the task entitled "Boater Decision Making" for the U.S. Coast Guard, for the period from May, 1976, through October, 1976.

Phase I presents the results from the analysis of 47 in-depth accident investigations involving capsizings, sinkings, and swampings to determine whether any common causes existed and if boat design changes would have prevented the accident.

Phase II gives results from interviews and observations of boaters in decision-making situations.

Phase III was an experiment directed toward determing the effect of boat design changes on a boater's risk-taking behavior.

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PREFACE

The U.S. Coast Guard and its contractors have recently undertaken research and development aimed at enhancing the safety of recreational boats. One particular area of interest to the Coast Guard is the capsizing, sinking, and swamping of small boats. The U.S. Coast Guard and Wyle Laboratories have undertaken work to: 1) determine whether any common causes for these accidents exist, and if so, 2) determine what sort of design changes in boats would have prevented these accidents, and 3) determine whether any behavioral problems (i.e., increased risk-taking) would result from making these design changes on boats.

The first two parts of this problem are addressed by the Coast Guard R&D Center Draft Report, "Safe Loading Operator Task Cause Identification Report" (Reference 1) and by Phase I of this report. In these reports, accidents from sources such as Wyle in-depth accident investigations and USCG Boating Accident Reports were analyzed to find the most frequent causes of these accidents. Once the probable causes involved in these accidents were determined, a team of experts analyzed the accidents to determine if, in their opinion, these accidents could have been prevented by a design change. Possible design changes were suggested, and an estimate was made of the effect of each design change in preventing accidents. These results have been tabulated and presented in Phase I.

Phases II and III of this report were aimed at answering the question, "What would be the effect of these boat design changes on boaters? Would the level of risk-taking increase and thus negate the capacity of these design changes to prevent accidents?"

Phase II of this report presents the results from interviews and observations designed to uncover associations between boat design, environmental exposure, and personal characteristics. Phase II gives an indication of the effect of various gross design differences on boaters' risk-taking behavior.

The third part of this report was an attempt to experimentally answer the question posed in Phase II. What would be the effect of specific design changes on boaters' behavior? While the results from Phase II gave us an idea of the effect of gross design changes on risk-taking, the question of the effect of more specific design changes remained. Phase III dealt with this question.

METRIC CONVERSION FACTORS

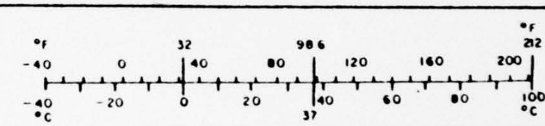
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly)

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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BOATER DECISION-MAKING — PHASE I
POTENTIALLY BENEFICIAL DESIGN CHANGES

1.0 INTRODUCTION

There are several projects underway under the direction of the USCG which are aimed at enhancing the safety of recreational boats. Much of this research concerns small craft such as johnboats, canoes, and small runabouts. Will this research actually help reduce accidents? Previous research has indicated that accidents are typically attributable to a combination of causal factors, rather than to a single cause. These causal factors can be categorized as follows:

- human and behavioral factors,
- equipment and boat design factors, and
- environmental factors.

Thus, accidents are caused by a complex system of events and circumstances. A thorough understanding of this system is needed in order to predict the outcome of a certain set of circumstances and events. Indeed, an action which may, on the surface, be expected to enhance safety, may, in fact, have undesirable consequences. If a boat design modification enables a boat to survive in rougher seas, boaters may then use that boat in seas which they would not have entered in another boat. In this case, the design factors in the accident system may be tending toward a safe outcome while the human and behavioral and the environmental factors might be tending toward an undesirable outcome; i.e., the boater may be overconfident because of the design change, and the environment may be poorer than any he may have experienced before. The interaction of these tendencies may produce an accident. Regardless of the size of boat, a boater who takes his boat out in rough water is exposing himself to a greater risk than in calm water. For this report, <u>risk-taking behavior</u> is operationally defined as taking a boat out in rough water. Thus, the improved safety in the design of the boat may actually lead to an increase in the frequency or severity of accidents due to an increase in risk-taking behavior by boaters and an increase in the severity of the environments they attempt to navigate.

The Phase I effort examines the frequency of capsizing/swamping accidents which may be preventable by improved boat design, assuming that the boats are not exposed to increased environmental hazards as a result of the modifications. The Phase II and Phase III efforts are concentrated on answering questions concerning the true effects of such design changes on risk-taking behavior, operator judgments, etc.

2.0 METHOD

A list of boat design characteristics which might be related to capsizings and swampings was compiled by polling Wyle and USCG personnel experienced in the investigation and analysis of such accidents, and from the "Recreational Boat Safe Loading - New Standard Development, Cause, and Identification Study" (Reference 1).

The list of design factors which might be involved in capsizing/swamping accidents was expanded to include other items of interest (weather, operator/passenger actions, etc.), and these were incorporated into a questionnaire/data form for data acquisition, as shown in Figure 1-1. The first section of the data form includes bookkeeping and general information. The information that the operator had prior to leaving the dock is contained in the foreknowledge section. Finally, the relevant behavior, weather, and boat factors are dealt with in the conditions section. Question 13 asks what boat design factors were involved in the accident, and whether changes in these factors could have prevented the accident. For example, if the forward well of a bowrider were filled by a wave, causing the bow to go down and swamp, then a design change to allow the bow compartment to self-bail may have helped. In this case, the idea was not to suggest covering the bow (resulting in a suggestion, essentially, to rule out bowriders as a safe design), but to adapt a bowrider design to enable it to survive this incident by making it self-bailing. The intent of this section of the data form was to gather information concerning modifications to existing designs, not to discuss new designs or redesigned craft.

Two experienced Wyle analysts were given the data form and instructions as to its intent and use. They read 47 Wyle in-depth capsizing/swamping investigation reports and recorded information on the form concerning:

- the boat design characteristics associated with each accident,
- the modifications of these designs which may have prevented each accident, and
- the other relevant information of the form which was available in the report.

DECISION-MAKING DATA FORM

Boat Type: ______________________ Length ____________

Operator Age: ______ Sex: M F Experience: 0-20 20-100 100-500 >500 hrs.

No. of passengers: __________ Gear on board (type and amount): __________

____

Activity (at the time of accident, and intended activity for the day) ______________

____

FOREKNOWLEDGE

1. Did the operator check the weather before heading out? Y N U
   Did he know what was out there; or, was he familiar enough with the area to know what to expect? Y N U

2. Did anyone suggest conditions might preclude going out, a passenger, other person, or did the operator think such a thing and reject it? Y N U

3. What were the primary motivations for the outing? (list/discuss) ______________

____

____

____

CONDITIONS

4. When did the operator become aware of the conditions (explain)? ______________

____

____

5. Was wave action involved in the accident? Y N U

6. After leaving, was turning back considered, and with what result (explain)? ______

____

____

7. Where did water first enter the boat? ______________

____

FIGURE 1-1. DATA ACQUISITION FORM

3.4 Design Modifications/Changes

8. How did operator/passengers react? ______________________________

____

____

9. List any factors (especially pertaining to the boat — "I've taken her out in weather like this before") which are known to have influenced the operator's behavior. __________

____

____

____

10. State weather conditions: Water temperature __________

Air temperature __________

Waves __________

Wind __________

Other (rain, etc.) __________

As forecast? Y N U

11. Was environment considered extreme for this body of water? Y N U

12. Was boat design ever mentioned as a factor in this accident? If so, how (if different from responses above)? Y N U

____

____

13. Check any (or all) of the following if (a) they were involved in the accident to a significant degree, and (b) if design changes in these areas could have prevented the accident (in a tidal wave, water over the bow was involved, but design changes probably wouldn't have helped).

Water getting into boat....	(a)	(b)
over the bow	____	____
over the side	____	____
over transom	____	____
thru holes (in motor well or elsewhere)	____	____

FIGURE 1-1. DATA ACQUISITION FORM (CONTINUED)

4.0 SUMMARY OF PHASE I

Water in the boat....	(a)	(b)
movement of water creates instability	______	______
water in bilge, unable to bail or drain	______	______
forward well of bowrider filled	______	______

FIGURE 1-1. DATA ACQUISITION FORM (CONCLUDED)

Each analyst read every accident report and recorded data independently. Disagreements were noted by comparing the data forms for each accident from the two analysts, and these differences were resolved by them in conference to yield a consensus of information about each accident. There were few disagreements between the analysts. The few that there were typically involved whether or not a design change could have prevented the accident, which was often a matter of expert opinion rather than objective reasoning on the part of the analysts. The cases of disagreement were discussed until all the analysts involved could agree. Thus, the data reflect a high degree of agreement between the analysts, and represent their best judgment in cases which are not clear-cut.

3.0 RESULTS

The following pages show the compilations of the results of the accident reviews by the analysts, and additional information. The results of the accident reviews were combined with those in Reference 1 and projected onto the overall capsizing/swamping accident population for 1974 and 1975, as defined in CG-357 (Reference 2). These projections yielded the overall statistics which accompany those from the expert analyses in the tables concerning the involvement of boat design characteristics (Question 13). The results will be broken down, question by question, and grouped according to their order of appearance on the data form in the discussion which follows.

3.1 Background Information

The first section of the data concerned the identification of the accident situation and boaters. Background information was gathered on questions such as the size of boat, and the age and background experience of the operator.

Table 1-1 shows the number of operators from the 47 in-depth capsizing/swamping accidents in each of three age categories and the expected number in that category based on CG-357 capsizing/swamping statistics for 1974 and 1975. A chi-square statistic computed for these data proved to be insignificant ($\chi^2 = 4.59$, $p > 0.10$); thus, there is no evidence to conclude that the ages of the operators from the 47 in-depth investigations are distributed differently than those from capsizing/swamping accidents reported in CG-357 for 1974 and 1975.

TABLE 1-1. OPERATOR AGE: 47 IN-DEPTH vs. CG-357 CAPSIZING/SWAMPINGS

	Age			
	Under 25	26-50	Over 50	Total
From 47 In-Depths	6.0	30	11.0	47
Expected Based on CG-357	12.4	26	8.6	47

Table 1-2 presents the same type of data for boaters' experience. The chi-square based on these data is statistically significant ($\chi^2 = 9.18$, $p < 0.025$). This indicates that the boaters in the 47 in-depth investigations typically had more boating experience than the average boaters in the CG-357 capsizing/swamping data.

TABLE 1-2. BOATER EXPERIENCE: 47 IN-DEPTHS vs. CG-357 CAPSIZING/SWAMPINGS

	Experience				
	Under 20 hrs	20-100 hrs	100-500 hrs	Over 500 hrs	Total
From 47 In-Depths	2.0	6.0	19	19.0	46*
Expected Based on CG-357	6.6	11.3	14	14.1	46

*Note: There was one unknown on this question.

Table 1-3 shows the same type of categorization of data for boat length. The chi-square statistic computed for these data is marginally significant ($\chi^2 = 5.41$, $0.10 > p > 0.05$), indicating some tendency for the boats from the in-depth investigations to be shorter than typical boats from CG-357 involved in capsizing/swampings, due to the lack of boats over 26 ft (7.9 m). There was very little difference between the observed and expected frequencies for boat lengths less than 26 ft (7.9 m).

TABLE 1-3. BOAT LENGTH: 47 IN-DEPTHS vs. CG-357 CAPSIZINGS/SWAMPINGS

	Boat Length			
	Less Than 16 ft (4.9 m)	16-26 ft (4.9-7.9 m)	26 ft (7.9 m) And Over	Total
From 47 In-Depths	25.0	22.0	0.0	47
Expected Based on CG-357	21.7	20.5	4.8	47

The previous three comparisons were between the data from the 47 in-depth accidents and the capsizing/swampings data from CG-357, and they show that: 1) the operators in the 47 in-depth investigations were not unlike typical capsizings/swampings operators in terms of age, but they had more experience, on the average, than the CG-357 capsizing/swamping operators; and, 2) there is a marginally significant tendency for the boats in the 47 in-depth accidents to be shorter, due mostly to the absence of boats over 26 ft (7.9 m) in the in-depths.

The operators in all 47 in-depth investigations were males. Data from the Accident Recovery Model show that over 75% of the accident victims are males, and probably a higher percentage of the operators are, although that fact is not available in ARM.

Table 1-4 displays the data for the 47 in-depth investigations and CG-357 concerning boat type. For the CG-357 data, the expected number for each boat type is shown based on capsizing/swamping accidents only.

TABLE 1-4. BOAT TYPE: 47 IN-DEPTHS vs. CG-357 CAPSIZING/SWAMPINGS

	Boat Type			
	Open Motorboat	Cabin Motorboat	All Others	Total
From 47 In-Depths	42.0	4.0	1.0	47
Expected Based on CG-357 Capsizing/ Swampings	27.5	6.4	13.1	47

The data were broken down into only three categories because there were so few boats in the 47 in-depth investigations which were not open motorboats, and the expected frequencies within a category should not be small in order to perform the chi-square test. Open and cabin motorboats, and "other" were the only three categories in CG-357 whose expected frequencies in 47 boats involved in accidents were five or greater. The chi-square statistic computed for the comparisons of the 47 in-depths to the CG-357 capsizing/swamping data ($\chi^2 = 19.72$, $p < 0.005$) is significant. The 47 in-depths are not representative of the capsizing/swampings in CG-357 in terms of boat type. There are more open motorboats in the in-depths than would be expected based on CG-357 and very few "others."

Table 1-5 lists the data for people on board from the 47 in-depth investigations and the expected number for capsizing/swamping accidents based on the USCG Safe Loading Cause Identification Research Study (Reference 1).

TABLE 1-5. POB: 47 IN-DEPTHS vs. USCG-SLCIRS

	Number of POBs				
	1-2	3	4	5 or More	Total
Data from 47 In-Depths	24.0	12.0	6.0	5.0	47
Expected Frequencies from USCG-SLCIRS	22.0	12.7	7.0	5.3	47

Note: $\chi^2 = 0.38$, $p > 0.90$

The results (shown in the note beneath the table) reveal that the data from the 47 in-depths coincide very well with the people on board data from the USCG R&D Center's investigation of loading-related accidents.

Table 1-6 below lists the data from the 47 in-depths and CG-357 (1975 only) concerning the type of operation or activity at the time of the accident, including expectations from CG-357 in capsizing/swampings. The data show that the 47 in-depth investigations are not representative of the typical capsizing/swamping victims in terms of their activity at the time of the accident. Basically, there are more of the 47 in-depths that were fishing or drifting than one would expect based on CG-357.

TABLE 1-6. ACTIVITY: 47 IN-DEPTHS vs. CG-357 OVERALL AND CAPSIZING/SWAMPINGS

	Activity			
	Cruising	Fishing/Drifting	All Others	Total
Data from 47 In-Depths	16.0	24.0	7.0	47
Data from CG-357 Capsizing/Swampings	17.6	15.5	13.9	47

NOTE: $\chi^2_{C/S} = 8.23$, $p < 0.02$

The list below shows the mean amounts of different types of gear on board by weight in the 47 in-depth investigations. In total, the mean weight of gear on board was almost 370 lb (167.8 kg).

•	Motor	165.9 lb	(75.3 kg)
•	Fishing Gear	58.4 lb	(26.5 kg)
•	Anchor	16.1 lb	(7.3 kg)
•	Fuel	72.3 lb	(32.8 kg)
•	Other	56.5 lb	(25.6 kg)
	TOTAL	369.2 lb	(167.5 kg)

The data concerning the gear on board cannot be compared with data from CG-357 or another source because no source for this type of data could be found. The data are shown in order to indicate the types of accidents covered in the in-depths. The people in these accidents typically carried several hundred pounds of gear including fishing equipment. Items frequently included under "other" were food, beverages, ice chests, and PFDs.

Table 1-7 lists the mean and mode (most frequent value) for several of the variables considered in the general information section for the 47 in-depth investigations. These data are tabled as part of the summary to characterize the in-depths on several of the important variables.

TABLE 1-7. MEANS AND MODES

Variable	Mean Value	Mode (Most Frequent Value)
Boat Length	15.96 ft (4.9 m)	15 ft (4.6 m)
Operator's Age	42.25 yrs	46 yrs
Operator's Experience	100-500 hrs	100-500 hrs
People on Board	2.81	2
Amount of Gear Aboard	369.2 lb (167.5 kg)	--

In summary, the background information section collected data to enable the description of the population used in determining potentially important boat design modifications. This background information from the 47 in-depth investigations shows that those accidents are not very representative of capsizings and swampings in CG-357 in terms of the operator's experience, boat type, and activity at the time of the accident. In terms of boat length, the in-depths contain no boats over 26 ft (7.9 m) and lack representativeness in that respect. In terms of people on board, the 47 in-depths were very

representative of the CG-357 population. Some of the differences between the in-depths and the CG-357 data may be due to the greater accuracy inherent in an in-depth investigation and to the sampling of the in-depths.

It was anticipated that the in-depths might be a biased sample. The in-depths are biased toward smaller open runabouts with experienced fishermen aboard. The in-depths were used because so much information was available in them. The information needed in succeeding sections was not available on BARs or other data sources. Therefore, the 47 in-depths constitute our sample, and the sample has biases. However, these biases are in the direction of the most frequent occurrences, as seen in Table 1-7: small boats, open runabouts, etc. This means that the analyses that follow apply only to the subpopulation that is represented by the 47 in-depth accidents, and not to the population of capsizing/swamping victims in general. The biases preclude the projections of these results to a population as large as that covered by CG-357. Indeed, it was the projections from CG-357 to these data that demonstrated the biases. Thus, if we weighted the data to take care of the bias in boat length, we would then lose our representativeness in people on board and might increase the bias that already exists on another variable, such as operator experience.

Having acknowledged that the data apply only to the subpopulation represented by the 47 in-depth investigations, the analyses continue with the results of the review of the in-depths in terms of the weather and design questions.

3.2 Foreknowledge Questions

The first three numbered questions dealt with the operator's awareness of the weather conditions and his motivations for going boating.

The motivations for the outings were primarily activity oriented. Table 1-8 below lists these. It is readily apparent that most of the boaters in the 47 in-depth investigations were on fishing trips.

TABLE 1-8. MOTIVATIONS FOR THE OUTINGS

Fishing Trip	40
Clamming Trip	1
Camping Trip	1
Scuba Diving	1
Pleasure Ride	2
Other	2

In 33 out of the 35 known cases, the weather was check before heading out; in 12 cases this information was uncertain or unknown. In most cases where the information was available, the operator probably knew what to expect in terms of the weather. Question 2 revealed that in 34 of the 38 known cases (there were nine unknowns), the operator did not consider the weather an important enough factor to preclude going out. The weather forecast was as forecasted in 21 out of 24 cases (23 unknowns) and the environment was not considered extreme for the particular body of water concerned in any of the 47 cases. However, in 10 of the 21 cases where the weather was a forecasted, the weather was poor (windy, rough, too rough for this craft, etc.). In four of these 10 cases, one of the people involved in the accident (wife, passenger) mentioned the fact that the conditions might have been too poor for the outing, yet the operator continued.

3.3 Conditions (Water Entry) Behavior

The bulk of the information gathered in the review of the 47 in-depth investigations concerned the actual conditions at the time of the accident and the possible design modifications which may have prevented the mishap.

In the detailed weather information gathered, most factors were not significantly different for the 47 in-depths from what would be expected from CG-357. The data for wind conditions were marginally significantly different, favoring stronger winds for the in-depths than for typical CG-357 accidents (see Figure 1-2).

The design changes or modifications that were indicated in the in-depth investigations and in Table 1-13 involve preventing water entry and allowing water to

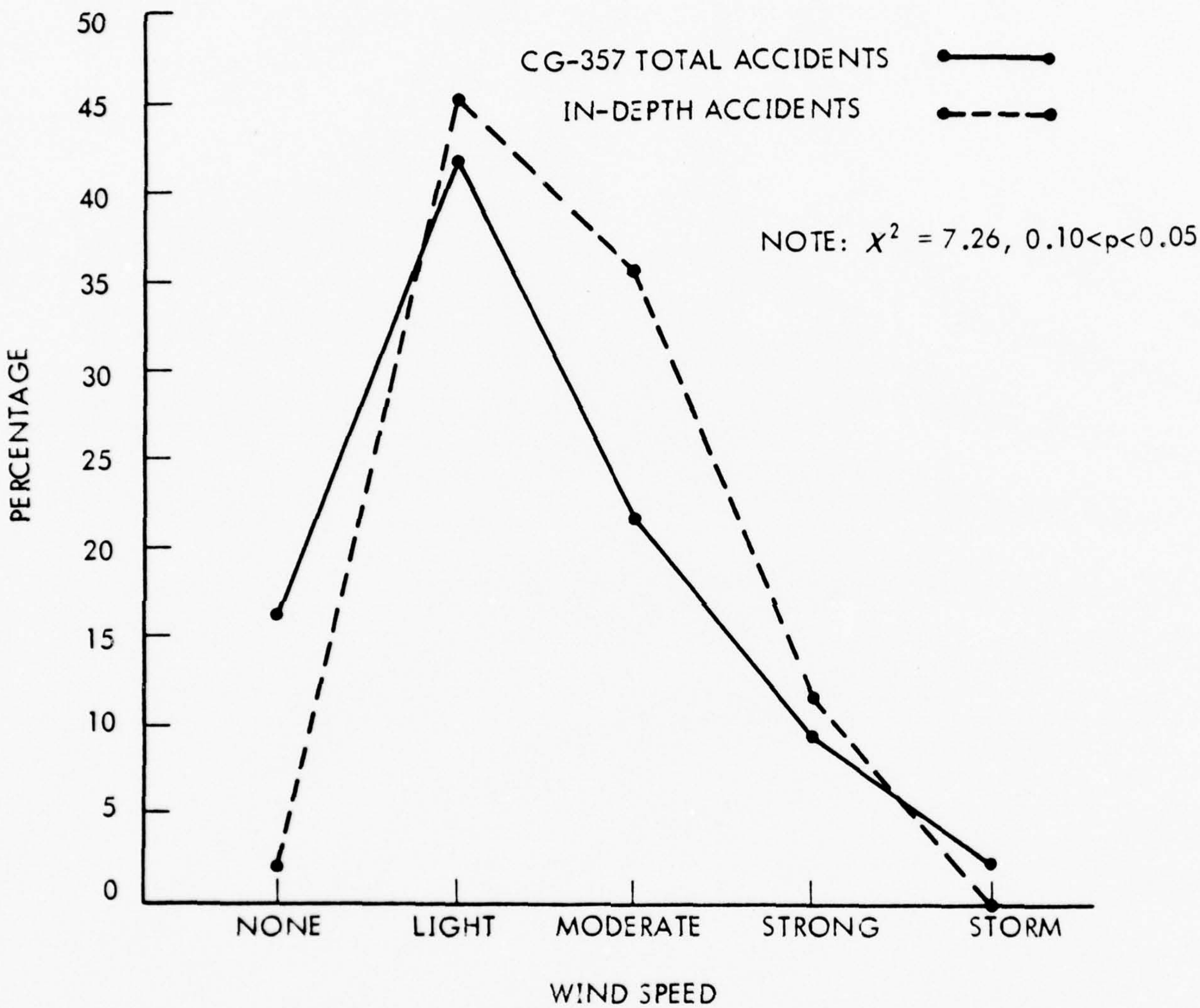

FIGURE 1-2. WIND CONDITIONS

escape a partially or fully swamped boat. The design changes or modifications include: increased freeboard (particularly at the transom), larger (or at least some) motorwell, and self-bailing compartments (particularly on bowriders).

Over half of the in-depths occurred in calm water, with about one-quarter in choppy water, and the rest spread over rough, very rough, strong current, and unknown. This breakdown was not significantly different from the proportions in CG-357 ($\chi^2 = 0.81$, $p > 0.50$). Table 1-9 shows the frequencies with which boaters encountered different wave heights in the 47 in-depths. Almost one-quarter of the known cases occurred in four foot (1.2 m) waves or higher.

TABLE 1-9. WAVE HEIGHTS IN 47 IN-DEPTHS

Wave Height	Frequency
0.0-1 ft (0.0-0.3 m)	12
1.1-2 ft (0.3-0.6 m)	14
2.1-3 ft (0.6-0.9 m)	4
3.1-4 ft (0.9-1.2 m)	3
4.1-5 ft (1.2-1.5 m)	3
Over 5 ft (1.5 m)	7
Unknown	4

Table 1-10 shows that the operators in the 47 in-depths never became aware of adverse or potential accident conditions on their way out to their activity - it was usually while they were doing their activity (typically fishing). As stated before, four of the operators were warned by another party not to go out, but they did not become aware of the conditions themselves until later. Eight operators either never were aware of the water/weather conditions or became aware only after the accident; and yet, in 40 out of the 47 cases, wave action was involved in the accident. After leaving the dock area, turning back was considered by only seven of the 42 known cases (five unknowns).

TABLE 1-10. WHEN DID THE OPERATOR BECOME AWARE OF THE CONDITIONS?

On the way out	0
While out	26
On the way back	13
None of the above	8

The water entered these boats from all possible angles. Table 1-11 shows the breakdown of where the water first entered the boat. The most frequent location was the stern or transom, but all locations had at least a few occurrences.

TABLE 1-11. LOCATION OF FIRST ENTRY OF WATER

Side (Unspecified)	4	14
Port Side	4	
Starboard Side	6	
Bow	9	
Stern or Transom	19	
Capsized	5	

In the 47 in-depth investigations, there were 32 cases where the people stayed with the boat after the capsizing/swamping, and one case where two people stayed while two people left. There were 14 cases where everyone left the boat. In only one of the 32 cases where the people stayed with the boat did they attempt to re-right it.

Table 1-12 below lists the factors which were known to have been a primary influence on the operator's behavior. Overconfidence and trust in one's experience (particular experiences or general experience) influenced 32 out of 41 known cases. The cases involving experience were closely related to overconfidence in the fact that the operator typically believed that his behaviors in similar circumstances in the past would enable him to deal with present conditions, or, his general knowledge would enable him to avoid problems.

TABLE 1-12. FACTORS INFLUENCING OPERATOR'S BEHAVIOR

Past experience (particular)	15
Past experience (in general)	10
Inexperience	9
Overconfident	7
Unknown	6

3.4 Design Modifications/Changes

In 23 out of the 47 accidents, boat design was mentioned in the in-depth investigation as a factor in the accident. Design changes would have prevented the accident or at least stopped the water from entering the boat in 21 of the 47 cases, and in those circumstances where water in the boat affected the accident, 12 out of 22 of these effects were preventable by design changes. Table 1-13 displays the results for Question 13, concerning whether an item was a factor in the accident to a significant degree, and whether design changes or modifications in these areas could have prevented the accident.

TABLE 1-13. DESIGN CHANGES/MODIFICATIONS

	...was a factor in the accident	...could have been prevented by a design change
Water getting into boat:		
over the bow	9	2
over the side	9	2
over the transom	23	12
through holes	6	5
Water in the boat:		
movement of water creates instability	6	4
water in bilge; unable to bail or drain	9	6
forward well of bowrider filled	7	2

4.0 SUMMARY OF PHASE I

The data form was designed and used to gather detailed information concerning capsizing/swamping victims and their decision-making processes, the influence of weather, the influence of boat design, and the implications of possible boat design modifications. Thus, Phase I provided data to be used in analyzing boater decision-making in Phases II and III. The data form was used to analyze 47 in-depth investigations of capsizing/swampings. These constituted the only data source available with sufficiently detailed information. Though this source had virtually all of the information needed, it was biased in several ways: the wind in these accidents tended to be more severe than in most accidents; the operators tended to be more experienced; the boats were typically of shorter length; the open runabout occurred too frequently in the sample for it to be truly representative of all capsizing/swampings. The biases pose interesting problems, such as the trend (in this sample) for experienced boaters to go out in stronger winds, in smaller open boats. Thus, while the data do not represent all of the target population (all capsizing/swamping victims), they do represent a sample where the biases are known and the data are relatively complete. These data indicate that weather information, even when available and known to the operator, often does not influence his decision concerning whether or not to venture out. The operators in the in-depth reports went out whether the forecast was for good or bad weather. Some boat design changes, such as increased freeboard, larger motorwells, and self-bailing compartments, might have prevented about half of these accidents. However, these data do not reveal whether these design changes would have influenced any of the decisions of these operators. There is some indication (Table 1-12) that the boaters in the in-depth reports were overconfident or relied too heavily on past experience in deciding what actions to take.

BOATER DECISION-MAKING — PHASE II
INTERVIEWS AND OBSERVATIONS

1.0 INTRODUCTION

In Phase I of our investigation, some of the details 47 accidents were studied to determine design changes that could have prevented the accident and to provide some detailed data on the decisions made in those accidents. Phase II and III of this report were directed toward evaluating the effect of the suggested design changes and other data from Phase I on the boater's behavior. What factors does a boater consider important in his decision to boat during marginal conditions? If a boat that was made safer through design changes was made available to the public, would the average boater feel more inclined to boat in these and even rougher conditions, thus negating the effect of having a "safer" boat? An understanding of the factors underlying these and other problems could help prevent many capsizings, swampings, and sinkings.

2.0 PROCEDURE

The purpose of Phase II was to collect information in an actual boater decision-making situation on factors affecting a boater's decision to boat during marginal conditions. From this data, it should be possible to identify the factors influencing a boater's decision.

Two decision-making situations were chosen for data collection. One decision-making situation was the transition point between rough and calm water. A photographer/observer was employed to record data on a boater's behavior upon reaching a transition point. The boat's characteristics and boater's behavior upon reaching rough water were recorded. Observations were taken on both rough and calm days to provide a control (calm day) and an experimental condition (rough day).

Certain advantages and disadvantages of this method should be noted. Boaters are totally unaware that they are being observed; therefore, their behavior reflects what they normally do under these conditions. However, the data collected under these conditions is of a rather limited nature. We are able to observe such gross features as boat length, number of people on board, type of boat, etc., and from this determine whether there are any trends for a particular type or size of boat to be used in rough weather. We can infer that something about these boats' characteristics is contributing to boaters' taking additional risks in rough seas. However, it would not be valid to conclude that because of these boat design characteristics alone a boater is taking a greater risk. Other factors must be considered in conjunction with boat design factors. Factors that could also enter into a boater's decision-making criteria are basic personality characteristics such as risk-taking tendencies and ability to handle stressful situations, the boater's motivation for boating on that day, or a score of other personal factors that might be affecting the boater on that day. For instance, a boater might feel let down if he didn't make the trip because he had been planning it for so long, or a fisherman knew that fishing was good in a particular area, or a hundred and one other good reasons. How do the personal factors interact with boat design factors and thus affect risk-taking behavior? In order to find out what personal factors might be involved in a boater's decision and

exactly what sort of criteria boaters use in making their decision, it was necessary to interview boaters.

The second type of decision-making situation chosen for data collection was at boat launch ramps and marinas. Boat launch ramps and marinas were chosen because they provided us with boaters to interview that would be close to the situation that we are interested in learning about, thus leading to a high degree of credibility in the answers.

The questions concerned:

1) weather conditions affecting decision,
2) water conditions affecting decision,
3) boat design factors affecting decision, and
4) other personal factors affecting decision.

These four subjects seemed to cover all areas that a boater might consider before or during an outing. All questions were open-ended so as not to bias answers in any direction. Boaters were encouraged to give as few or as many answers as desired. The boaters responded well to the questionnaire. Very few people refused to participate and most people were quite helpful.

One problem encountered with use of the questionnaire was a possible bias in the conservative direction. Many boaters assumed that the interviewers were with the local law enforcement agency, and in many cases it was difficult to convince them otherwise. Thus, many times interviewers felt that answers were bent toward proving to the interviewer that the boater was "a very safety conscious person."

Sites were chosen across the country to represent major boating areas with top priority given to areas with the highest rates of capsizing, swamping, and sinking accidents. Second, boaters were chosen to represent a range of geographical areas and water types. Third, sites used were those where wave buoys had been set out by the Coast Guard in order to obtain accurate information on wave conditions.

Based on these criteria plus proper weather conditions (a good chance of rough seas) and a good area from which to observe boaters, the following sites were used for collection of data: St. Joseph, Michigan; Belle Isle, Michigan; Cape May, New Jersey; Port Aransas, Texas; and Pt. Judith, Rhode Island.

3.0 RESULTS — OBSERVATIONS

A total of 1081 boats were observed and photographed in weather conditions including both calm and rough days. A br^ ..down of the number of observations on rough versus calm days revealed that a total of 816 boats were observed on calm days and 265 boats on rough days. Calm day observations were more numerous due to several factors. Even though every attempt was made to obtain as many rough day observations as possible, often the weather proved to be unpredictable. As a result, nine calm days and four rough days were used for observations. Rough days would logically produce fewer boats due to the weather, thus fewer observations were obtained. All field observations were conducted on weekends in order to maximize the possible number of observations.

Comparisons were made between observations made on rough days and calm days. Any differences obtained in type of boats out can be attributed to the rough weather if we assume that all other relevant factors such as operator experience, personal factors, etc., are distributed randomly over the two types of data.

A comparison was made to determine whether the observed boats were representative of boats normally involved in capsizing/swamping. If the boat length for the observed boats is compared to CG-357 capsizing/swampings, the data shows that the observed boats are not representative of the typical capsizing/swamping victims in terms of boat length ($\chi^2 = 7.82$, $p < 0.025$). Most of the contribution to the chi-square comes from having too few boats less than 16 ft (4.9 m) and too many in the 16-26 ft (4.9-7.9 m) range in our sample.

A comparison was made between the boats that were out on rough versus calm days according to boat length. The mean boat length for the calm days was 18.39 ft (5.6 m) and for the rough days was 19.94 ft (6.1 m). The mode (most common boat length) was 16 ft (4.9 m) for both calm and rough days. If the difference in mean boat length between the two sea conditions is tested for significance, a t test reveals a highly significant ($p < 0.001$) difference.

Table 2-1 gives the breakdown for the number and percentage of boats in various size ranges that were boating on rough versus calm days. This table shows that a higher percentage of boats under 16 ft (4.9 m) will be out on calm days than rough days, and that a higher percentage of boats greater than 26 ft (7.9 m) will be out on rough days. A chi-square test ($\chi^2 = 12.39$, p υ.01) of this result is significant, indicating that a smaller percentage of the boats out on rough days are small. Boats in the range of 16 ft to 26 ft (4.9 to 7.9 m) showed little difference in their tendency to be out on rough or calm days, while a larger percentage of the boats out on rough days were large (over 26 ft (7.9 m)).

TABLE 2-1. BOAT LENGTH vs. TYPE OF DAY

	Boat Length			
	≤16 ft (4.9 m)	>16 ft-≤20 ft (4.9-6.1 m)	>20 ft-≤26 ft (6.1-7.9 m)	>26 ft (7.9 m)
Calm	397 (49%)	245 (30%)	112 (14%)	62 (08%)
Rough	109 (41%)	79 (30%)	39 (15%)	38 (14%)

An examination of Figure 2-1 shows the breakdown for sizes of boats on rough versus calm days and a comparison between percentages of boats by boat length that were boating on rough versus calm days. Boat sizes were determined from the photographs using manufacturer's names and personnel familiar with the craft. The figure shows that on calm days, a much higher percentage of boats out were 15 ft (4.6 m) and under. A surprising part of the graph is that boats 16 and 18 ft (4.9 and 5.4 m) long made up a greater percentage of boats out on rough days than on calm days.

It was possible to make a comparison of the type of boats that ventured out on rough and calm days. Boats were classified as either cabin, runabout, bowrider, or open. (If a comparison of the type of boats out on rough versus calm days is made (Table 2-2), a higher percentage of the boats that were out on the rough days as opposed to the calm days were cabin boats, while a higher percentage of the boats that were out on calm days as opposed to rough days were open boats.) This result was significant ($\chi^2 = 5.15$, $p < 0.025$). If, however, the percentage

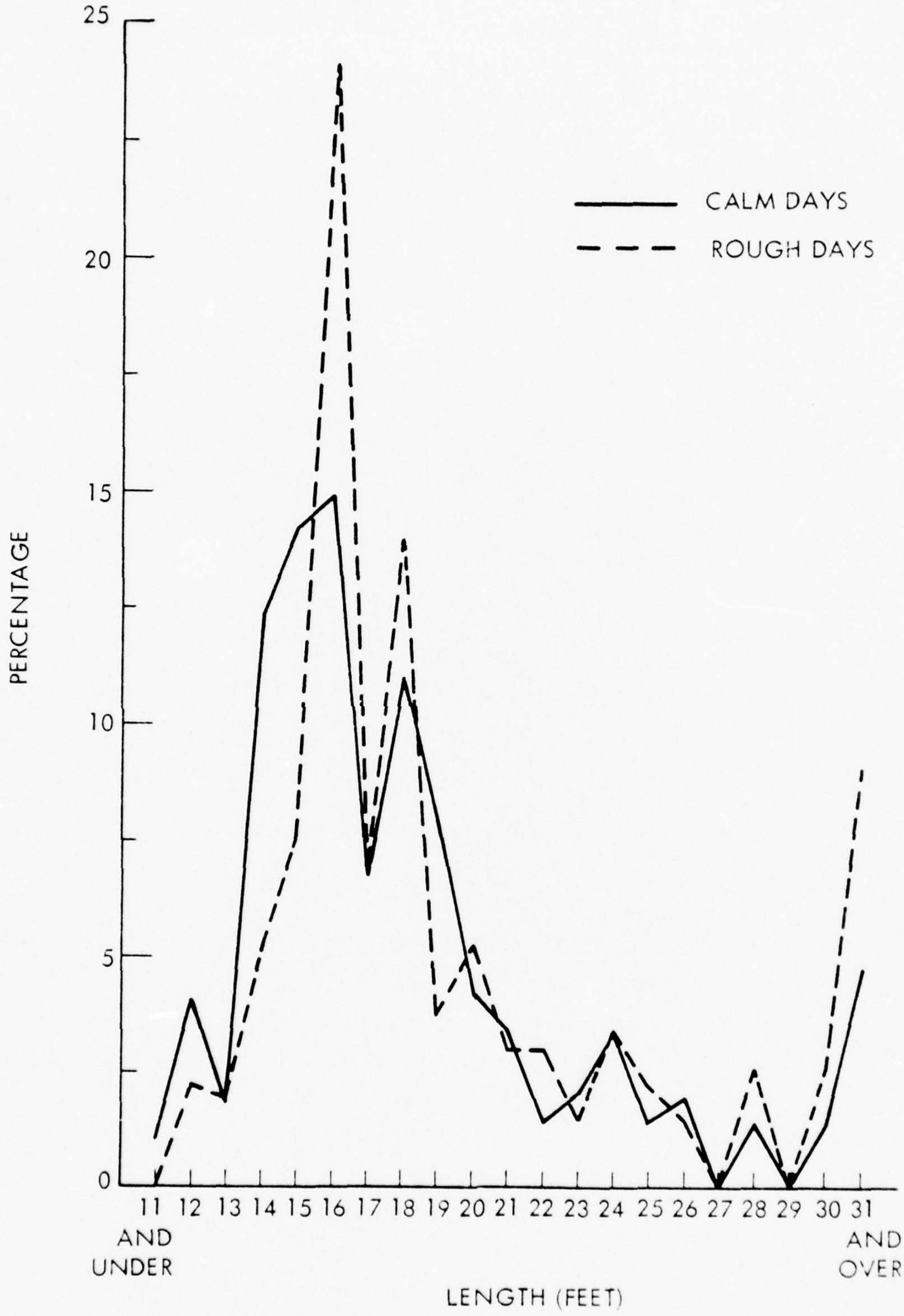

FIGURE 2-1. TYPE OF DAY vs. BOAT LENGTH

of bowriders and runabouts that were out on rough versus calm days is compared, virtually no difference is found (Table 2-3, $\chi^2 = 0.075$, $p > 0.5$). This demonstrates a lack of dependence on water conditions for the relative presence of bowriders and rounabouts.

TABLE 2-2. BOAT TYPE (CABIN AND OPEN) vs. TYPE OF DAY

	Boat Type	
	Cabin	Open
Calm	94 (47%)	108 (53%)
Rough	74 (60%)	49 (40%)

TABLE 2-3. BOAT TYPE (RUNABOUT AND BOWRIDER) vs. TYPE OF DAY

	Boat Type	
	Runabout	Bowrider
Calm	137 (64%)	108 (53%)
Rough	82 (66%)	77 (34%)

From the pictures of boats out on rough and calm days, it was possible to pick out boats which were photographed close enough and in such a position as to tell whether or not the boat possessed a motorwell. Since these boats represent a random sample from our population, it is possible to compare the number of boats with and without motorwells on rough versus calm days (Table 2-4). This result proved to be statistically insignificant ($\chi^2 = 0.32$, $p > 0.5$), indicating no tendency for motorwells to be associated with rougher days.

From the observations, it was also possible to determine the PFD wear rate for rough and calm days. The PFD wear rate for calm days was 5.4% and for rough days was 5.6%. No significance ($\chi^2 = 0.01$, $p > 0.90$) was found in this result.

An attempt was made to document the behavior of boaters that were out on rough days. For instance, what type of boat is most inclined to venture out into rough seas versus what type is more inclined to turn around upon reaching rough seas?

TABLE 2-4. NUMBER OF BOATS WITH MOTORWELLS vs. TYPE OF DAY

	Boat Characteristics	
	Motorwell	No Motorwell
Calm	40 (70%)	17 (30%)
Rough	28 (78%)	8 (22%)

Boat length was compared to the boater's behavior upon reaching rough conditions. Table 2-5 shows the frequency and percentage of the total number of boats in each behavior category and how they reacted to the situation. Boater's behavior was classified according to whether he turned around before the rough water was reached or continued out into the rough water. Not all boats were observed in this circumstance, and the sample sizes reflect only those boats which were observed at the point of encountering rough water. Boat length seemed to have a significant ($\chi^2 = 11.53$, $p < 0.01$) effect on the probability that boaters turned around before reaching rough water. Most of the significance came from the fact that boats less than 16 ft (4.9 m) were much more inclined to turn around before reaching rough water while the larger boats (greater than 20 ft (6.1 m)) were more inclined to venture out for awhile. Boats between 16 and 20 ft (4.9 and 6.1 m) showed much less difference in their behavior upon reaching rough water. Figure 2-2 shows the breakdown for length versus behavior.

TABLE 2-5. BOAT LENGTH vs. BOATING BEHAVIOR

	Boat Length		
	≤16 ft (4.9 m)	>16 ft-≤20 ft (4.9-6.1 m)	>20 ft (6.1 m)
Turned around before reaching rough water	36 (65%)	16 (29%)	3 (05%)
Went out and turned back or went out	9 (35%)	9 (35%)	8 (31%)

Boater behavior is cross-classified by the type of boat that was used in Table 2-6. This result was also significant ($\chi^2 = 10.53$, $p < 0.025$) and shows that boat type seemed to have an affect on the boater's behavior upon reaching rough water.

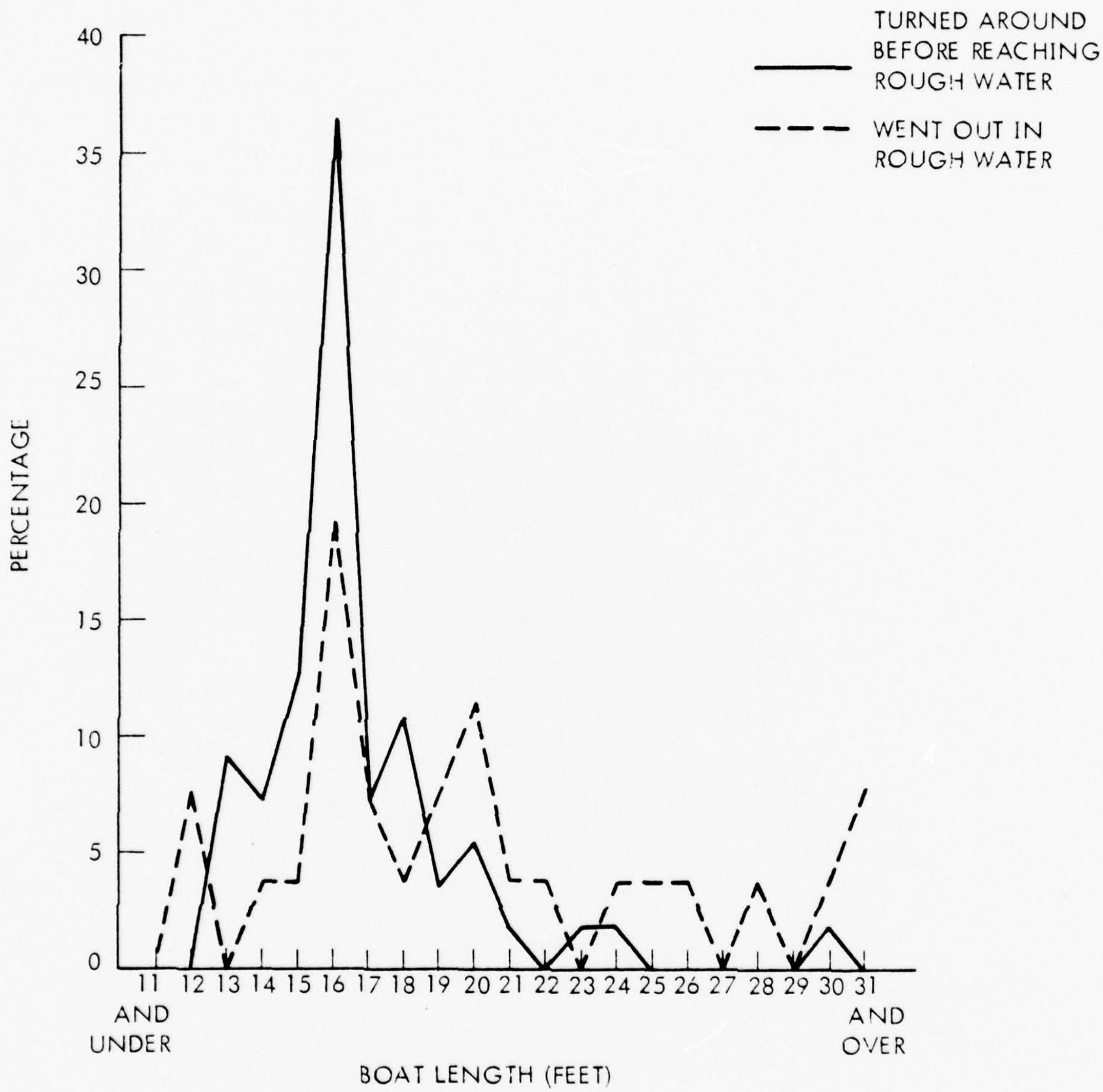

FIGURE 2-2. ROUGH DAYS - BOAT LENGTH vs. BOATING BEHAVIOR

PFD wear rate was not significantly different for the people who turned around as opposed to continuing out ($\chi^2 = 2.53$, $p > 0.10$).

TABLE 2-6. BOAT TYPE vs. BOATING BEHAVIOR

	Boat Type			
	Bowrider	Cabin	Runabout	Open
Turned Around	14 (25%)	5 (09%)	20 (36%)	16 (29%)
Went Out	4 (15%)	10 (38%)	8 (31%)	4 (15%)

4.0 INTERVIEW RESULTS

In order to supplement the information obtained from observations, interviews with boaters at boat launch ramps were conducted (Appendix B). Through these interviews, it is possible to gain insight into the decision-making process of boaters and the effect of such factors as experience and boat design on this process. It must be remembered in reviewing these data that some boaters did not respond to every question.

The 104 boaters that were interviewed were compared to the boaters in the Wyle 47 in-depth accidents and to the boaters in CG-357 capsizing/swampings. This comparison showed that the interview sample was slightly under-represented in the category of boats under 16 ft (4.9 m), over-represented in the 16-26 ft (4.9-7.9 m) category and under-represented in the over 26 ft (7.9 m) category. The reasons for this bias are that the areas selected for interviews/observations tended to represent areas with rougher weather; therefore, primarily operators of larger boats (greater than 16 ft (4.9 m)) were available to interview. Second, boats greater than 26 ft (7.9 m) were ignored in favor of the smaller (less than 26 ft (7.9 m)) boats available, due to the fact that this study was intended to answer the question of the effect of design changes on smaller boats.

The first decision point that a boater reaches is whether to go out at all. Questions were aimed at determing what sort of factors would prevent a boater from going out in the first place, such as: 1) the weather factors, and 2) other general factors such as personal reasons. Table 2-7 presents the types of weather factors given by those interviewed and the frequency of each type of response. By far the most frequently mentioned factor in the boater's decision-making process before going out was wind conditions. Boaters were asked whether other things might enter into their decision to go boating. Tables 2-8(a) and 2-8(b) list other factors mentioned that might influence a boater's decision to go out that day, or his decision to turn back once he had launched his boat. For Tables 2-7 and 2-8(a), frequencies are listed (rather than percentages) since some boaters gave multiple responses. The results of Tables 2-8(a) and 2-8(b) indicate that many of the boaters interviewed were interested in fishing and expressed concern for the safety of the people

aboard and the load in their boats. Conclusions based on Table 2-8(b) are tenuous at best since the boaters may have expressed the "right" answer for the benefit of the researchers rather than a true reflection of the decision-making process.

TABLE 2-7. WEATHER FACTORS

What sort of things in the weather would have changed your mind about boating today?

	Frequency of Answers
Water Conditions	2
White Caps	2
Rough Water	8
Severe Weather	2
Rain	26
Wind	92
Thunderstorms	22
Lightning	4
Small Craft Warnings	10
Dark Sky - Clouds	10
Fog	5
Heat	1
Barometer Change	2
Nothing	5

TABLE 2-8(a). OTHER FACTORS

Are there other things that you considered when deciding to go boating today?

	Frequency of Answers
Condition of:	
Boat	9
Motor	5
Fishing	20
Water	2
Personal Physical Condition	1
Distance to Ramp	2

TABLE 2-8(b). OTHER FACTORS

Would you turn back sooner if your family were aboard?

	Frequency of Answers	Percent of Total Answers
Yes	58	82.9
No	12	17.1

Would the load in your boat have anything to do with your decision?

	Frequency of Answers	Percent of Total Answers
Yes	47	73.4
No	17	26.6

Another area of concern is how a boater obtains information pertaining to conditions for boating on a given day. The question was asked of boaters: "Would you, or do you, ask other boaters about the water conditions, or go out and see for yourself?" The results are shown in Table 2-9.

TABLE 2-9. BOATING CONDITIONS INFORMATION ACQUISITION

	Frequency	Percent of Total Responses
Ask other boaters	41	28%
See for self	67	45%
Listen to weather reports	39	27%
	147	

Several of the questions from the interview were directed toward determining what sort of criteria a boater uses when making a decision to turn back due to rough conditions. For instance, boaters were asked if they had ever been exposed to a situation(s) where they were forced to turn around. If they had, the boater was asked to remember the situation(s) and tell what happened. If they had never been exposed to a turn-back situation, boaters were simply asked to list conditions that would cause them to turn back.

In analyzing these answers, it was decided that the reasons for turn-back could be broken down into three distinct decision criteria: 1) distal water cues - answers such as he saw rough water conditions ahead but did not proceed into them, or saw other boaters coming back, would fall into this category.

A chase boat was available and nearby at all times. Subjects were told that a

In other words, was there something that the boater saw before he reached rough water that caused him to turn back? 2) Weather cues - these were answers related to weather conditions. Did the operator cite changing sky conditions or increased wind conditions as the reason for turning around? 3) Proximal water cues - these were answers that had to do directly with water conditions. For example, water-related cues would be: people getting wet from spray, boat hard to handle, or water too rough. These were cues the operator could feel directly.

Overall, there was little difference among the three turn-around criteria on the frequency with which each were mentioned. Distal water cues are mentioned 57 times, weather cues 60 times, and proximal water cues 61 times.

A comparison was made to determine whether there was a difference in the turn-back criteria of boaters who had been exposed to turn-back situations versus boaters who had never been exposed to a turn-back situation.

The results showed that exposed people tended to rely on proximal water cues (53%) much more heavily than non-exposed people (24%). This result was significant ($\chi^2 = 4.07$, $p < 0.05$). Weather-related cues and distal water cues were not significantly favored by either the exposed or non-exposed boater.

Similar analysis was performed to find out whether boaters with less than 100 hours experience have different decision-making criteria than boaters with greater than 100 hours experience. These results were non-significant in terms of all three turn-back criteria.

An analysis was performed to determine whether boat design characteristics - namely motorwell versus no motorwell, and boat size - would have an affect on the boater's turn-back criteria. The results showed that boaters without a motorwell would use weather cues much more frequently than the motorwell boaters. This result was highly significant ($\chi^2 = 10.86$, $p < 0.001$). There was no significant difference between boaters with and without motorwells in terms of the use of distal or proximal water cues as turn-back criteria.

When boats were broken down according to size, less than 16 ft (4.9 m) or greater than 16 ft (4.9 m), weather cues were again found to be mentioned more often (64% to 41%) by boaters in smaller craft ($\chi^2 = 4.85$, $p < 0.05$). No significant preferences for distal or proximal water cues were noted for boats less than 16 ft (4.9 m) vs. greater than 16 ft (4.9 m).

The next part of the questionnaire was designed to find out boaters' reactions to possible design changes for their vessels. However, design changes were not suggested to boaters. It was felt that if boaters were told directly of some possible design changes for their boats to increase safety, then answers as far as the effect of such design changes on their behavior (i.e., increased risk-taking) would not be accurate. Therefore, questions were asked that would cause boaters to think in terms of design changes (i.e., Was your boat unstable or hard to handle at any time? Did any water enter the boat?). Then boaters were asked whether they could think of any boat design changes that they would make in order to make the boat safer in rough conditions. The results showed that over 70% of the boaters felt that their boat was already as safely designed as it could be and that the manufacturer had done the best job possible. The remaining 30% were asked to list some of the design changes that they might like to see. These possible changes are shown in Table 2-10.

The 30% who suggested design changes were asked if they would feel confident to take their boat out in rough conditions if these design changes were made. This question was asked in the context of a discussion of poor boating conditions (see Appendix B, Question 7). Note that the word "these" in the question refers to the rough conditions under discussion. Thirty-nine percent of this group responded affirmatively while 48% responded negatively. The remaining 13% didn't know. These results are shown in Table 2-11.

TABLE 2-10. DESIGN CHANGES

Is there something about your boat design that you would change in order to make it safer in rough conditions?

	Frequency of Answers	Percentage of Total Answers
Yes	31	29.8
No	73	70.2
Boat Design Changes		
More stable	1	
Higher sides	6	
Larger size	13	
Change hull shape	5	
Change from bowrider	1	
Add flotation	5	
Higher bow	2	
Patch holes in self-bailing well	1	
Flare bow	5	
Deeper hull	3	
Raise transom	4	
Add dead rise	1	
Open center	1	
Add self-bailer	2	
Widen it	3	

TABLE 2-11. DESIGN CHANGES EFFECTED

If these changes were made, would you feel confident to take your boat out in these or rougher conditions?

	Frequency of Answers	Percent of Total Answers
Yes	12	38.7
No	15	48.4
Don't Know	4	12.9

5.0 DISCUSSION AND CONCLUSIONS

The results of these interviews and observations have given some insight into how boaters obtain information and make decisions about boating conditions. For practical purposes, three decision points can be defined where an operator must decide to continue or turn back. This does not mean that a decision is made at just those points in time. Decision-making is a continuous process. However, this breakdown allows us to isolate factors that the operator considers at different points in time.

The first decision point that we are interested in exploring is before a boater leaves home. What information does he use in making his decision to leave home? The results from the interviews have provided a variety of answers, but the factor of wind conditions emerged as the most important in the boater's decision. Is this a "good" criteria for a boater to use? Results from Phase I suggest that wind conditions, while slightly higher for capsizing, swampings, and sinkings, are not abnormally high when these accidents occur. Therefore, wind conditions are not the only contributor to these accidents, and a boater's decision criteria should include other factors as well.

The second major decision point for boaters is at the launch ramp. Here the boater is confronted with the conditions he will face when boating. How does a boater obtain information for this decision? The results showed that close to 45% of the boaters were inclined toward a "see for myself" attitude, 27% would listen to weather reports, and 28% would ask other boaters. Some boaters expressed negative opinions about weather reports and small craft warnings that had been posted. They felt that these warnings too often turned out to be false or not consistent with their expectations.

The third and most important decision-making point is when the boater is actually enroute in his boat to his destination. At what point will the operator feel that the dangers inherent in proceeding outweigh the advantages? The results from the interviews and observations have indicated some particular boat characteristics that affect one's perception of his environment. The results from the observations showed that as the size of the boat increased,

the more hazardous were the water conditions to which the boater exposed himself. A similar result was obtained for boat type. The open boat operator displayed less risk-taking behavior (i.e., limited himself to calmer waters) than the cabin boat operator. A higher percentage of boats out in rough water were cabin boats while a higher percentage of boats out in calm water were open boats. The results of the observations on turn-arounds suggest that increasing boat size leads to an increase in risk-taking behaviors (i.e., going out in rough water).

The results from the interviews provide some support for these results. For instance, it was found that boaters with boats less than 16 ft (4.9 m) in length were more inclined to use weather cues as a reason for turning around. The results from the interviews also suggest that operators of boats without motorwells are more inclined to use weather cues as a turn-back criteria. If we can say that use of weather cues and distal water cues denote more cautious boaters than boaters who rely upon proximal water cues to turn back, then these results point out that boaters with boats less than 16 ft (4.9 m) and without motorwells use a more conservative judgment criteria in making decisions than boaters with boats greater than 16 ft (4.9 m) and with motorwells.

Further analysis of the results concerning the reasons for turn-back situations have shown experience is a factor which affects boaters' judgment. Less experienced boaters, specifically those who have never been exposed to a turn-back situation before, show a tendency to use a more conservative judgment criteria. The more experienced boaters use proximal water cues, suggesting that the more experienced boaters are exposing themselves to rough conditions before making a turn-back decision.

Evidence of the effect of specific design changes on people's behavior was also obtained from the questionnaire. These results showed that a portion of the boating population (39% of those who suggested design changes) would boat in rougher waters than they normally would if given the design changes they asked for, and some (13%) weren't sure.

The following conclusions can be drawn from Phase II:

1. Wind conditions are an important factor in a boater's initial decision to go boating.

2. A large number of boaters (45% from Table 2-9) have already made up their minds about boating before they get to the dock area. This suggests that in a large number of cases, a boater's decision is more a matter of needing conditions that will force him to turn around rather than the boater evaluating conditions beforehand.

3. Several factors were isolated as having an affect on a boater's judgment criteria. Boat size, boat type, and boater experience (in terms of exposed vs. non-exposed) were all found to have a significant affect on how a boater makes his decisions. As boat size and boater experience increased, and with boats with covered bows or cockpits, boater risk-taking behavior (i.e., venturing into rougher waters) increased. The results on the effect of motorwells on a boater's criteria were inconclusive.

4. Based on the results of this section, there is reason to believe that some boaters will feel safer and increase their risk-taking behaviors (go out in rougher water) if certain design changes are made.

BOATER DECISION-MAKING — PHASE III EXPERIMENT

1.0 INTRODUCTION

Phase III of the Boater Decision-Making Task was an experiment designed to evaluate the effect of several safety-related design changes in three small johnboats on boaters' behavior. Phase II shows that these gross design changes affect what boaters *say* they would do. Phase III *experimentally* evaluates the effect of certain design changes on boaters' *behavior*. Would boats with higher freeboard or increased stability lead to increased risk-taking behavior by boaters? One way to answer this question is to design an experiment whereby it is possible to manipulate particular design features of various johnboats and observe any changes in the risk-taking behavior of boaters.

2.0 EXPERIMENTAL EQUIPMENT

Boat designs were selected that seem to represent a broad spectrum of possible safety-related design changes, including some of the ideas suggested in Phase I. Boats used were as follows (see Table 3-1 for dimensions):

1. A semi-V johnboat (Figure 3-1). This boat was selected because of the V-hull's reputation for taking rough water better. With this type of hull, the boater might feel safer since he is not subjected to as much pounding as with an ordinary flatbottom johnboat and thus be encouraged to boat in rougher conditions.

2. A modified flatbottom johnboat (Figure 3-2). An ordinary flatbottom johnboat with higher freeboard, greater width and generally heavier and sturdier construction was used for the modified johnboat. A motorwell was added to enhance the safety features of this boat.

3. Our control johnboat (Figure 3-3) was a fairly narrow boat of lightweight materials. It was felt that this johnboat represented a sharp contrast to the modified johnboat in terms of stability, seaworthiness, and overall safety.

TABLE 3-1. DIMENSIONS OF JOHNBOATS

Boats Used	Center Length	Beam	Bottom Width	Center Height	Overall Capacities*		
					HP	PC	TC
Control Johnboat	12'6" (3.8 m)	46 in. (1.2 m)	33 in. (0.8 m)	14 in. (0.4 m)	7.5	321 lb (146 kg)	467 lb (212 kg)
Modified Johnboat	12 ft (3.7 m)	55 in. (1.4 m)	38 in. (1.0 m)	17 in. (0.4 m)	10.0	428 lb (194 kg)	568 lb (258 kg)
Semi-V Model	12 ft (3.7 m)	49 in. (1.2 m)	40 in. (1.0 m)	19 in. (0.5 m)	7.5	330 lb (150 kg)	470 lb (213 kg)

*HP = Horsepower
PC = Person's Capacity
TC = Total Capacity

FIGURE 3-1. SEMI-V JOHNBOAT

FIGURE 3-2. MODIFIED FLATBOTTOM JOHNBOAT

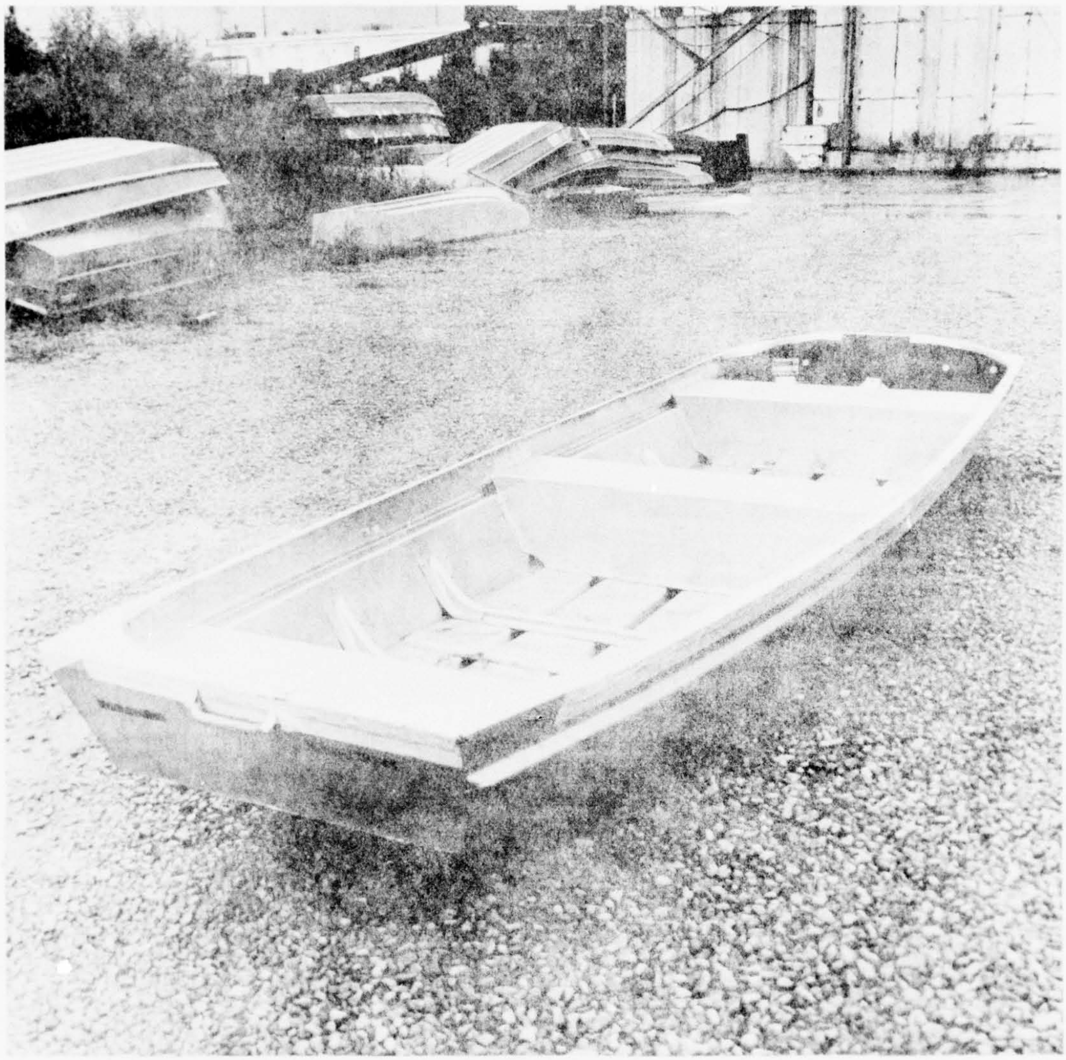

FIGURE 3-3. CONTROL JOHNBOAT

The equipment used on the johnboats was as follows:

- 1 - Cushion Type IV PFD
- 1 - Vest Type III PFD or Type II for subject's use
- 1 - Paddle
- 1 - Gas tank
- 1 - Outboard motor (6 or 9 hp)

Extra equipment used:

- 1 - Chase boat (employed to follow subjects on their outing)

3.0 EXPERIMENTAL PROCEDURE

The basic outline of this experimental design was to expose boating subjects to a variety of experimental conditions (i.e., water conditions) and to judge from their reactions to the situations whether the use of one johnboat is preferred over the others, and, if so, whether this use would lead to increased risk-taking.

Subjects were chosen from among Wyle personnel. The reason that subjects were chosen from Wyle was that the success of the experiment depended on attaining relatively rough water conditions. It was found that it was necessary to contact subjects on short notice for participation in the study; therefore, Wyle personnel proved to be the easiest to use.

Subjects were contacted on days when it appeared that water conditions would be fairly choppy and then driven to the study site.

Brown's Creek Sailing Club in Guntersville, Alabama, was chosen as the site from which to run the study. This site was chosen because: 1) cooperation from the owners of the sailing club was obtained which allowed us to store the johnboats and other equipment there; 2) Guntersville provides a fairly large body of water in which proper sea conditions had a good chance of occurring; 3) Guntersville Lake was within easy reach of Wyle Laboratories.

Subjects were told that their job was to rate the performance of each johnboat (see Appendix A). Boats were to be taken on a short trip (approximately 15 minutes) around Guntersville Lake. Subjects were told to handle the boat as they would normally on a short pleasure cruise. Instructions to the subjects emphasized that the object of this test run was not to test the boat to its limits, but simply cruise normally. Subjects were encouraged to react to the water conditions as they normally would - in other words, if they felt uneasy or uncomfortable at any time, they were encouraged to come back in. Figure 3-4 shows boaters at various times during the trials.

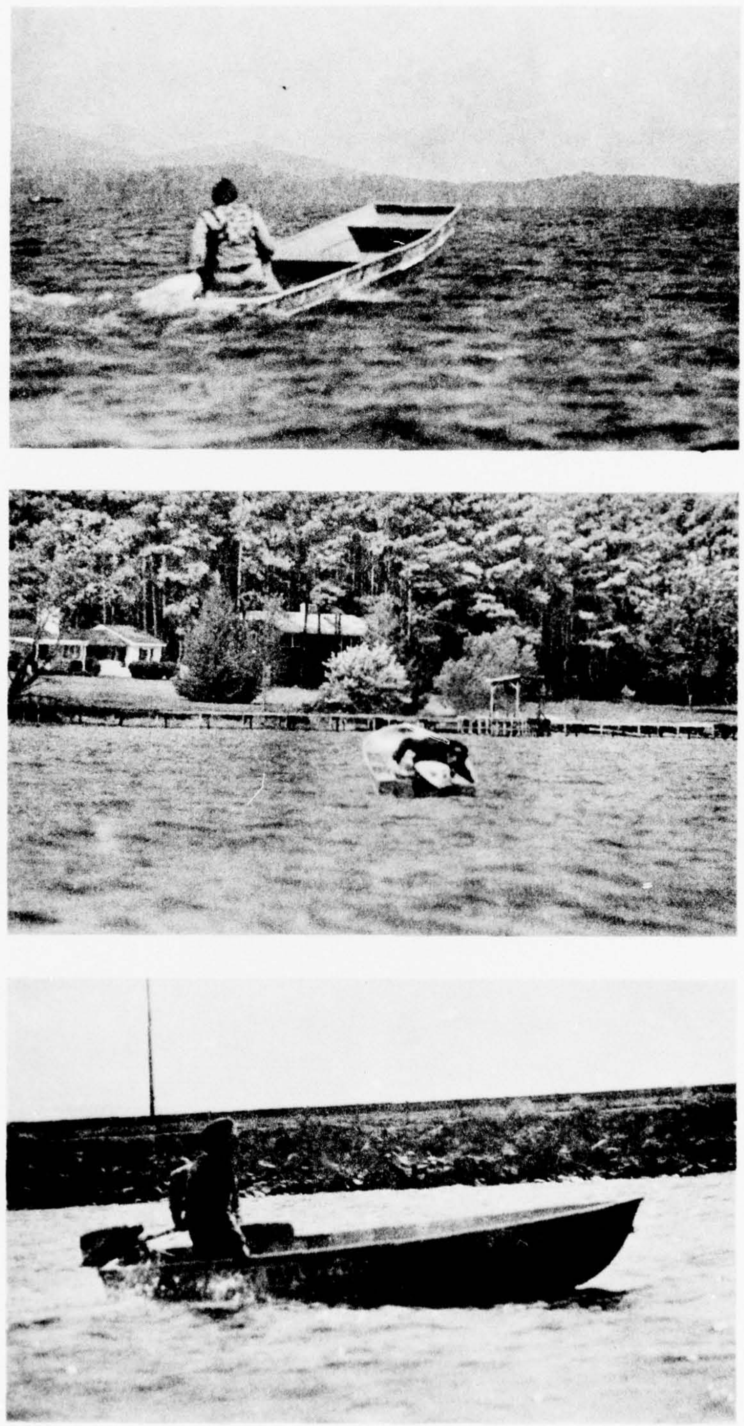

FIGURE 3-4. BOATERS AT VARIOUS TIMES DURING TEST RUNS

A chase boat was available and nearby at all times. Subjects were told that a chase boat would be nearby at all times in case anything went wrong. With this sort of precaution, there existed the possibility that subjects might take risks that they would normally not take. However, it was decided that subjects' behavior would not be influenced by the chase boat due to the fact that the prospect of being dumped in the water was adverse enough in itself. It was also decided that since boating would take place under poor weather conditions, it would be important to take good safety precautions and provide a safety boat at all times.

4.0 RESULTS

A total of eight different subjects with varying levels of boating experience were tested in all three johnboats in different weather conditions. The weat^h conditions would vary throughout the day. Sea conditions varied from a slight chop of three to six inches (7.6 to 15.2 cm) to conditions where white caps were visible and wave height was estimated at nine to twelve inches (0.2 to 0.3 m). Wind conditions varied from a low of 10 mph (16.1 kph) winds to gusts up to 20 mph (32.2 kph).

Subjects were brought to the boat launch area at staggered time intervals in order to minimize contact between subjects. When this was not possible, subjects were prevented from communicating about their boating experience to other subjects upon returning. Upon returning from each boating excursion, each subject filled out a questionnaire on his background experience (see Appendix C) and on questions pertaining to his experience with each particular boat (see Appendix D). Boaters were to rate each boat on a rating scale* according to seven different dimensions. These dimensions were as follow (see Appendix D):

1) Suitability of this boat for the weather conditions,
2) Stability of the boat at high speeds,
3) Stability of the boat at slow speeds,
4) Overall seaworthiness of the boat,
5) How comfortable the boat was for the conditions,
6) The boat's suitability for fishing, and
7) How safe the boat would be for taking other passengers (e.g., members of one's family).

Scores for each boat and subject were tabulated and comparisons made to determine any affects of boat type on behavior and attitudes. A Wilcoxon Test was run to find out the affect of each of the three boat types on the rating on each

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*The rating scale was developed based on psychological research in this area. Research (Reference 4) has shown that this number of divisions on the rating scale is an optimum number to use. A greater number of divisions produces results of no greater accuracy.

dimension. All results were non-significant at $p > 0.1$ which indicates that, overall, subjects found no differences among the boats. If a breakdown is made according to the type of water conditions each boat was exposed to, an analysis of variance (F-Test) can be run to determine whether the severity of water conditions had an effect on the scoring for each boat. No statistically significant ($p > 0.75$) results were obtained.

A comparison was made to determine the extent of subject variability in the results. Two subjects were selected who had used the boats in two different water conditions. One subject displayed a clear tendency to rate two of the boats higher than the other one in rough sea conditions. The other subject displayed no clear-cut change in preference in rougher sea conditions. The subjects showed different preferences in calmer sea conditions.

The second type of result obtained concerned whether any turn-back situations were encountered by boaters. No turn-backs due to rough conditions were noted on any of the runs. All boaters said that they never felt in danger or felt uncomfortable enough to turn back.

After the boaters had completed the test runs with all three boats, each subject was asked, "Would you take one of these boats out in rougher conditions? If so, which one?" Five out of eight of the subjects responded affirmatively with three people picking the modified johnboat; one person, the V-hull; and one person, the control boat.

Finally, the subjects were asked, "Consider a situation where you were forced to use one of these boats; which one would you prefer?" Again, the modified johnboat was the preferred boat with five people picking the modified boat; two people, the V-hull; and one person, the control johnboat.

5.0 CONCLUSIONS

The results from the questionnaire have shown how certain design changes are perceived by boaters. The questionnaire probed boaters' feelings that the modified johnboat was more comfortable than the control boat or semi-V boat, and the effects on risk-taking behavior if a boat felt safer due to increased control and a more comfortable ride.

The results have shown that, after exposure to a variety of water conditions and to a wide selection of experienced and inexperienced boaters, no clear-cut preference of one boat over another was evident in either the answers to the questionnaire or in number of turn-backs encountered. These results, however, cannot be taken as conclusive proof that these design changes would have no affect on risk-taking behavior. Several problems with running this type of experiment were encountered.

1. It was felt that the results from the experiment might have been affected by the fact that sea conditions were not rough enough to warrant any turn-back behavior. Since no turn-back behavior was recorded, sea conditions might not have been rough enough to test the safety features of the boats. The results from the follow-up question ("Would you take one of these boats out in rougher sea conditions?") indicate that this might have been the case. Five out of the eight subjects indicated that they would indeed venture out into rougher conditions. In addition to this, there was a clear-cut preference for the modified johnboat over the others. These two factors led us to believe that lack of rough enough sea conditions was indeed a factor in the results.

2. Questions were raised in the minds of the experimenters as to whether boaters would normally react to a real-life situation as they did during the experiment. Even though subjects were encouraged to turn back whenever they felt the need, it was possible that subjects still felt obligated to finish testing the boats and thus take risks that they normally would not. It should also be pointed out that to a certain extent the decision to

boat that day had already been made for them. They had been brought to the boating area and had given up a considerable amount of work time to participate.

3. As pointed out in the results section, subject variability proved to be a major factor in our results. While one boater felt that one boat handled better in rough conditions, another boater may have felt there was no difference. Variability such as this can affect results significantly in experiments with small N (number of subjects).

The question of the effects of certain design changes on boaters' behavior has not been conclusively answered by this experiment. From Phase II (Table 2-11) the conclusion was reached that boats which boaters perceived as safer might lead to increased risk-taking behavior. The question remains as to whether specific design changes are perceived as increasing the safety of the boat. For the water conditions in the experiment, no clear differences in safety were perceived among the boats by the subjects. In rougher conditions, some differences among the safety of the boats might be perceived. The results to the follow-up question suggest this, with five out of eight subjects stating that they would have taken at least one of the test boats out in rougher conditions. Therefore, a larger experiment with more subjects and better (rougher) testing conditions would produce more conclusive results and provide evidence to support or reject the idea of behavioral changes resulting from boat design modifications.

BOATER DECISION-MAKING — PHASE IV
THE THREE SUBTASKS IN PERSPECTIVE

In order to operate a small craft safely, the boater must be able to: 1) detect and identify objects and conditions in his environment; 2) make decisions as to the appropriate courses of action; and 3) execute those decisions.

Basically, there are two types of decisions that a boater must make: 1) decisions about the credibility of the information he is recieving, or the nature of it; and 2) decisions as to a course of action. The former type of decision does not result in a course of action, but rather a choice as to what information to use in deciding a course of action. This type of decision is called a judgment. An example would be the following: Suppose you saw a small craft in the fog or haze that was approaching you, but the other operator was slowing down so he sounded like he was moving away from you (i.e., the character of the sound was changing toward lower frequencies and less volume). In this situation, you must decide whether to believe your eyes or your ears. Once this decision is made (a judgment), then you must decide what to do. This latter decision is of type No. 2; it is a choice as to course of action.

Decision-making is a continuous process, but we can conceive of three logical locations for the boater to decide whether to go boating. First, he could decide not to leave home. From the review of the in-depths, the questionnaires, and the behaviors of the experimental subjects, it appears that such a decision is a rare occurrence. Subjects (on calm days) were asked if they ever planned to go boating and then decided not to because of weather. The subjects in this research usually preferred to judge the weather for themselves <u>once they were out in the water</u>. A second decision point would be at the water's edge. Here the boater might decide to return home from the sight of the conditions from the launch area. Here again, the commitment to boat is strong once the boater's "mind is made up," and reversals due to weather/water conditions are atypical. In the in-depth investigations, four boaters continued out into the water even though a person or persons questioned their decision to do so, considering the poor weather conditions. Do boaters turn around while on their way out? Some do, but many did not in the reported research. It seemed that if one boater braved the conditions, they all did. The motivation for the weekend fisherman to go boating is very strong. The outing may be planned for

several days and enable the boater to escape his trials and tribulations, and enjoy a free afternoon. Psychological research indicates that people are generally reluctant to change decisions anyway. This, combined with the motivational factors, leads to the kind of data that have been witnessed, such as the fact that none of the 47 operators in the in-depth investigations that were reviewed noticed any unsafe conditions until their outings were well underway. Thus, although decision-making is an active and continuous process, it may take an inordinate amount of information to persuade the boater to turn into port because of the motivational and psychological inertia.

From the large psychological literature on decision-making, there are two results of considerable importance in the light of the results of Phases I, II, and III of this effort (see References 5 and 6). The first of these is the repetition phenomenon. When the boater is asked to repeat his decision several times during the week (such as when a friend says, "What are you going to do this weekend?"), his position is strengthened with each repetition. He may turn down another activity because he is already planning to go boating. Psychologically, that makes his decision to go boating that much tougher to reverse because of adverse conditions. If the outing was planned to be a family excursion, then similar events may be happening to the wife and children, building considerable motivational and psychological inertia. The second major result from the decision-making literature is that active participation in a decision leads to persistence in the position taken. A boater who buys provisions for his outing (food, beverages, bait, etc.), cleans and readies his boat, checks weather forecasts, sets out his clothes and gear, is actively participating in his decision to go boating. Again, if this is a family outing, the family is probably actively participating in getting ready to go also. One of the strongest findings in the psychological literature concerning decision-making is that such active participation makes the decision very difficult to change. Thus, the literature suggests that once a boater and/or his family have decided to go boating, and made the appropriate preparations, it may be very difficult to alter that decision, regardless of the weather or the boat design. Our results (the rare occurrence of boaters deciding to stay home, the "see for myself" attitude, and their slowness to recognize the seriousness of a hazardous situation in the in-depths) are consistent with the psychological theory.

The motivational and psychological factors may cloud the boater's judgments (the information used in decision-making) as well, further lessening the chances of a "turn-back" decision. The significance of experience that surfaced in this research is further evidence of this, since the more experienced operator may have been exposed to these conditions before, and survived, so his perception of them may be a less cautious one than a less experienced boater. He uses his perceptual information, his memories of similar situations and past experience in making his judgments.

From the experiment, it is not clear if boat design factors can influence behavior. However, the results of all three subtasks suggest that a considerable amount of evidence is needed to convince a boater not to go out, or to turn back once he is out. The additional factor of making a boat more seaworthy or reducing the probability of an accident in moderate circumstances may tend to cause the boater to need that much more evidence of unsafe conditions before changing his decision. Even though the decision-making process is continuous, there is a sense in which the decision is made once the boater plans to go out, and something striking or dramatic is needed to convince him that another decision is needed. With "safer" (modified) boats, the dramatic or striking event may need to be even more threatening than before. This is a concept that might be tested in future research.

We have data concerning several aspects of the decision process, but data concerning the magnitude of the event needed to cause a re-evaluation and second decision are needed. The experiment that was conducted did not provide these data, at least in part, because no conditions were encountered that were rough enough to cause such a re-evaluation. The data do indicate that even experienced small boat operators need to be reminded of the potential dangers of small craft, especially in poor weather, and that their decision to go boating should be re-evaluated as objectively as possible once they start out and as weather conditions change. Of course, other factors such as fatigue and alcohol may, over the course of the day, influence his abilities to make judgments and decisions, and his skill, so that what was a relatively "safe" set of conditions on the way out may be more dangerous when he returns, after exposure to the stressors of the boating environment.

Further research is needed to control the motivational, psychological, and environmental influences as much as possible, to manipulate them, and to design a program to allow and encourage boaters to make better and more objective decisions concerning their boating activities.

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APPENDIX A — SUBJECT CONSENT FORM

To the potential subject: The experimenter asks that you read the following material carefully and consent, if you so decide, by signing in the space provided below. You may decline if you so decide without fear of penalty or prejudice toward yourself.

1) The research in which you have volunteered to participate as a subject involves the following procedures:

   We would like you to take each boat out on whatever course you choose for approximately twelve minutes. You'll be given a stopwatch so you can gauge your time. You should operate the boat safely, as you would on a normal outing with family or friends.

2) The purposes of these procedures are:

   We would like you to test each of three johnboats. The purpose of this test is to evaluate the johnboat's stability, seaworthiness, comfort, and performance under power. You will be asked to fill out a rating scale for each boat after you return.

3) The procedures to which you will be exposed in this research involve the following discomforts and risks:

   Do not try to test the limits of the boat. The experimenter will tell you which areas of the lake to avoid because of seaweed and in which areas you can expect to encounter rough water. Wear your PFD at all times in case you should inadvertently enter the water.

The experimenter will now be glad to answer any questions you may have concerning these procedures.

You are free to withdraw your consent and discontinue participation in this research at any time without penalty or prejudice.

______________________	______________________
Subject's Signature	Experimenter's Signature

APPENDIX B. INTERVIEW FORM

Fishing/Hunting _____ Cruising _____ Skiing _____

Boat length _____ Type/Model ____________________

Mfg ____________________ No. POBs _____

Op. sex _____ Adult _____ Teenager _____

Experience (Hrs): _____ Under 20 _____ 20-100

_____ 101-500 _____ Over 500

1. What sort of things in the weather would have changed your mind about boating today?

____

____

2. Are there other things that you considered when deciding to go boating today?

   Previous plans _____
   Distance to ramp _____
   Get away from house _____
   Fishing is good _____
   Other ____________________

3. Ask other boaters about water conditions? Go out and see for yourself?

____

____

4. Water conditions? (If rough AFTER, go to No. 12.)

____

CALM

(Ask if above answer is calm or if it is BEFORE and answer is rough.)

5. Have you ever gone out and turned back because you thought it was too rough? (If no, go to No. 8.)(If yes, ask questions below.)

   White caps _____
   Water enter boat _____
   People get wet from spray _____
   When turn back ____________________
   Saw rough water _____
   In it for some time or distance ____________________

6. What happened? What made you decide to turn back?

____

____

Did any water enter the boat over the bow, sides, transom? Did the boat feel unstable or hard to handle?

____

____

7. Is there something about your boat design that you would change in order to make it safer in rough conditions? Like what?

____

____

If these changes were made, would you feel confident to take your boat out in these or rougher conditions?

_____ Yes _____ No _____ Don't know

GO TO CAPACITY QUESTIONS (NO. 15)

8. What conditions would make you turn back or seek shelter?

   White caps _____
   Thunderstorm _____
   Lightning _____
   Increase in wind speed _____
   Change in sky _____
   Other ____________________

9. Would you turn back sooner if your family were aboard?

   _____ Yes _____ No

10. Would the load in the boat have anything to do with your decision?

   _____ Yes _____ No

11. Do you feel your boat is as safely designed as it could be for rough water?

   _____ Yes (Go to capacity questions - No. 15)

   _____ No - Why not? (Refer to No. 7, if needed.)

ROUGH AFTER

12. What made the water rough?

   Wind _____
   Wakes _____
   Storm _____ Sudden Storm _____
   Other ____________________

13. What happened? (If answer is staved out, go to No. 8.) Why did you turn back? Water enter boat over bow, sides, or transom? Boat feel unstable - hard to handle?

____

____

____

14. Is there something about your boat design that you would change in order to make it safer in rougher conditions? Like what?

____

____

____

If these changes were made, would you feel confident to take your boat out in these or rougher conditions?

_____ Yes _____ No _____ Don't know

CAPACITY QUESTIONS

15. Without looking at capacity plate can you tell me:

a. How much total weight?

_____________ Estimate _____________ Actual

b. How many people?

_____________ Estimate _____________ Actual

c. What is the maximum horsepower?

_____________ Estimate _____________ Actual

16. Where is your capacity plate located?

____

17. What kind of life preservers do you have on your boat?

Cushion _____
AK-1 _____
Vest _____
Jacket _____
Other ______________________________

18. Do you think life preservers are important?

_____ Yes _____ No

19. How often do you wear one?

____

20. Where do you keep your life preservers?

____

21. Have you ever taken a boating safety course?

_____ Yes _____ No

What kind?

____

22. What is your occupation?

____

TO BE COMPLETED BY INTERVIEWER:

Boat No. ______________________

Motorwell? _____ Yes _____ No

Self-bailing bowrider? _____ Yes _____ No

Self-bailing cockpit? _____ Yes _____ No

APPENDIX C.

BOATER DECISION MAKING QUESTIONNAIRE

PART A

Name______________________________ Date__________ __________

Boating Safety Instruction: _____None _____USCG Auxiliary _____Red Cross _____Other

_____Power Squadron _____State ______________________________ (Specify)

Boating Experience: _____Under 20 hours _____100-500 hours _____20-100 hours _____Over 500 hours

Do you own a boat? _____Yes _____No Type__________________ Length_______ Power_______(hp)

Primary Boating Activities: _____Pleasure Cruising _____Fishing _____Canoeing/Kayaking

_____Water Skiing _____Sailing _____Other ______________________________ (specify)

SWIMMING ABILITY: _____Nonswimmer _____Intermediate _____Advanced

Boat Used: ____________________ Safety Equipment Taken: ______________________________

Amount of Course Completed (Diagram below if necessary)

Time until completion or decision to turn back____ ____(min.)

Comments:

APPENDIX D.

PART B

Please answer each of the following questions by circling the number which best summarizes your opinion.

1. How suitable are the weather and water conditions today for boating in a small craft of the type you just used?

1	2	3	4	5
Very Safe	Safe if you're careful	Safe only for experienced boaters	Hazardous	Very Hazardous

2. How would you rate the boat you just used on directional stability and general stability at high speeds in the present conditions?

1	2	3	4	5
Very Stable	Stable if you don't shift your weight suddenly	Slightly Unstable	Unstable, you must be very careful	Very Unstable

3. How stable was the boat you just used at rest and slow speeds under the present conditions?

1	2	3	4	5
Very Stable	Stable if you don't shift your weight suddenly	Slightly Unstable	Unstable, you must be very careful	Very Unstable

4. How seaworthy was the boat you just used under the present conditions? For example, how well did it handle the waves? Did it take on water?

1	2	3	4	5
Very Seaworthy	Seaworthy if you use common sense in operating it	Could capsize or swamp if you're not careful	Likely to capsize or swamp if you're not careful	Likely to capsize or swamp

5. How comfortable was the rougher part of your ride in this boat today? Consider spray, pounding, difficulty in holding on, etc.

1	2	3	4	5
Dry and comfortable	A little spray or pounding	Moderate spray, or pounding	Lots of spray, hard pounding	Excessive spray and pounding, very uncomfortable

6. How suitable would the boat you just used be for fishing on a day like today? Suppose that you and a friend were going to sit out there with the boat anchored for several hours.

1	2	3	4	5
Very stable and comfortable	Some roll, but stable	Moderate roll, feels unstable at times	Often feels unstable, uncomfortable	Dangerously unstable and uncomfortable

7. How would you feel about taking small children or your family out pleasure cruising in the boat you just used on a day like today?

1	2	3	4	5
Perfectly Safe	A little choppy, but not really unsafe, would take them	Choppy, would take them only if necessary	Rough, probably would not take them	Definitely would not take them, too dangerous